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(71) Applicant: BATTELLE MEMORIAL INSTITUTE [US/US]; Pacific Northwest Division, Intellectual Property Services, P.O. Box 999, Richland, WA 99352 (US).

(72) Inventors: GILBERT, Ronald, W.; 65105 N. Demoss Road, Benton City, WA 99320 (US). ANDERSON, Gordon, A.; 1104 Christopher Lane, Benton City, WA 99320 (US). STEELE, Kerry, D.; 610 N. Hartford, Kennewick, WA 99336 (US). CARRENDER, Curtis, Lee; 1110 Country Ridge Drive, Richland, WA 99352 (US).

(74) Agent: MAY, Stephen, R.; Battelle Memorial Institute, Pacific Northwest Division, Intellectual Property Services, P.O. Box 999, MSIN: K1-53, Richland, WA 99352 (US).

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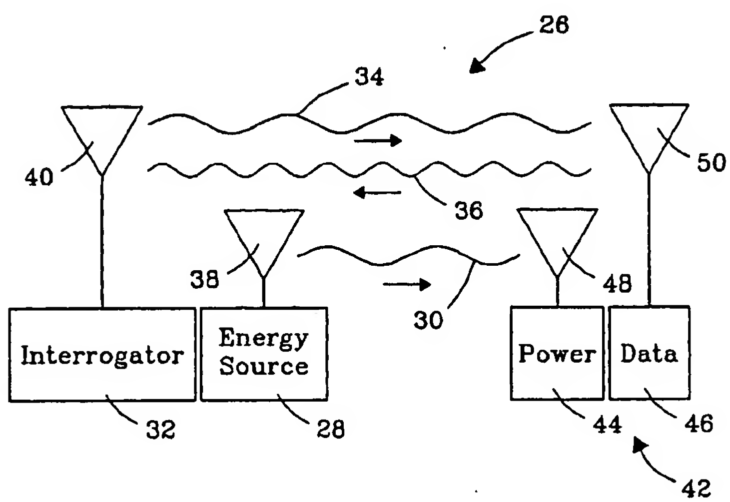
(54) Title: REMOTE COMMUNICATION SYSTEM AND METHOD



(57) Abstract: A remote communication device is provided that includes an antenna configured to receive a first signal and a second signal at different frequencies and to transmit a third signal; a power circuit coupled to the antenna and configured to provide a supply voltage from the first signal; and an identification circuit coupled to the antenna and the power circuit and configured to use the supply voltage to generate the third signal. Ideally, the first and second signals are received simultaneously through a single antenna, which may also be used to transmit the third signal. Alternatively, a first antenna is used to receive the first signal and a second antenna is used to receive the second signal and transmit the third signal. In one embodiment, an energy signal is transmitted at a first frequency to a tag where it is rectified and used by the tag to receive the second signal at a second frequency and to transform the second signal into the third signal for transmission at the second frequency or at a different frequency. The energy signal may be from a parasitic source, such as wall current, existing radio waves, or from natural or artificial light.

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REMOTE COMMUNICATION SYSTEM AND METHOD

FIELD OF THE INVENTION

The present invention pertains to a remote communication system, and, more particularly, to a radio frequency (RF) identification system and method that provides remote energy to an RF identification tag at a first frequency and communicates data signals to and from the tag at a second frequency.

BACKGROUND OF THE INVENTION

Remote communication utilizing wireless equipment typically relies on radio frequency (RF) technology, which is employed in many industries. One application of RF technology is in locating, identifying, and tracking objects, such as animals, inventory, and vehicles.

RF identification (RFID) tag systems have been developed to facilitate monitoring of remote objects. As shown in Figure 1, a basic RFID system 10 consists of three components, an antenna 12, a transceiver with decoder 14, and a transponder (commonly called an RF tag) 16. In operation, the antenna 12 emits electromagnetic radio signals generated by the transceiver 14 to activate the tag 16. When the tag 16 is activated, data can be read from or written to the tag.

In some applications, the antenna 12 is a component of the transceiver and decoder 14 to become an interrogator (or reader) 18, which can be configured either as a hand held or a fixed-mount device. The interrogator 18 emits the radio signals 20 in range from one inch to one hundred feet or more, depending upon its power output and the radio frequency used. When an RF tag 16 passes through the electromagnetic radio waves 20, the tag 16 detects the

signal 20 and is activated. Data encoded in the tag 16 is then transmitted by a modulated data signal 22 through an antenna 24 to the interrogator 18 for subsequent processing.

An advantage of RFID systems is the non-contact, non-line-of-sight capability of the technology. Tags can be read through a variety of substances such as snow, fog, ice, paint, dirt, and other visually and environmentally challenging conditions where bar codes or other optically-read technologies would be useless. RF tags can also be read at remarkable speeds, in most cases responding in less than one hundred milliseconds.

There are three main categories of RFID tags. These are beam-powered passive tags, battery-powered semi-passive tags, and active tags. Each operate in fundamentally different ways.

The beam-powered RFID tag is often referred to as a passive device because it derives the energy needed for its operation from the radio frequency energy beamed at it. The tag rectifies the field and changes the reflective characteristics of the tag itself, creating a change in reflectivity that is seen at the interrogator. A battery-powered semi-passive RFID tag operates in a similar fashion, modulating its RF cross section in order to reflect a delta to the interrogator to develop a communication link. Here, the battery is the source of the tag's operational power. Finally, in the active RFID tag, a transmitter is used to create its own radio frequency energy powered by the battery.

A typical RF tag system 10 will contain at least one tag 16 and one interrogator 18. The range of communication for such tags varies according to the transmission power of the interrogator 18 and the tag 16. Battery-powered tags operating at 2,450 MHz have traditionally been limited to less than ten meters in range. However, devices with sufficient power can reach up to 200 meters in range, depending on the frequency and environmental characteristics.

Conventional RF tag systems utilize continuous wave backscatter to communicate data from the tag 16 to the interrogator 18. More specifically, the interrogator 18 transmits a continuous-wave radio signal to the tag 16, which

modulates the signal 20 using modulated backscattering wherein the electrical characteristics of the antenna 24 are altered by a modulating signal from the tag that reflects a modulated signal 22 back to the interrogator 18. The modulated signal 22 is encoded with information from the tag 16. The interrogator 18 then demodulates the modulated signal 22 and decodes the information.

Conventional continuous wave backscatter RF tag systems utilizing passive (no battery) RF tags require adequate power from the signal 20 to power the internal circuitry in the tag 16 used to modulate the signal back to the interrogator 18. While this is successful for tags that are located in close proximity to an interrogator, for example less than three meters, this may be insufficient range for some applications, for example greater than 100 meters. Hence, there is a need for a passive RF tag system that can generate adequate power from received signals for longer range communication of the modulated signals.

SUMMARY OF THE INVENTION

The present invention provides a remote communication system that includes a remote communication device having an antenna configured to receive a first signal and a second signal at different frequencies and to transmit a third signal; a power circuit configured to provide a supply voltage from the first signal; and an identification circuit coupled to the antenna and the power circuit and configured to use the supply voltage to generate the third signal for transmission by the antenna.

In accordance with another aspect of the present invention, the antenna may be configured to have a single antenna to receive first and second signals and transmit a third signal, or it may have a first antenna to receive the first signal and a second antenna to both receive the second signal and transmit the third signal. Ideally, the first signal is at a frequency that is lower than the frequency of the second and third signals.

In accordance with another aspect of the present invention, the power circuit is configured to rectify the first signal into a supply voltage, such as a DC supply voltage for supplying a DC current.

In accordance with another aspect of the present invention, the antenna is configured to receive a first signal that is in the form of either radiated light energy, a magnetic field, or electromagnetic signals, such as radio frequency signals.

In accordance with another embodiment of the invention, a remote communication system is provided that includes a source of radiated energy; a transceiver configured to transmit a first data signal and to receive a second data signal; and a transponder configured to receive the radiated energy and convert the radiated energy into a supply voltage that is used to receive the first data signal and to transmit the second data signal. Preferably, the transponder is configured to transform the first data signal into the second data signal.

In accordance with another embodiment of the invention, a remote communication method is provided that includes receiving an energy signal and converting the energy signal into a supply voltage; receiving a first data signal at a frequency that is different than the frequency of the energy signal; and transforming the first data signal in accordance with a predetermined transformation scheme into a second data signal and transmitting the second data signal, all using the supply voltage converted from the energy signal. Preferably, the energy signal and the first data signal are received simultaneously.

In accordance with a further aspect of the method of the present invention, the energy signal is converted by rectification into a DC supply voltage for generating a DC current. The transformation of the first data signal is preferably performed by modulating the first data signal into the second data signal in accordance with a predetermined modulation scheme.

As will be readily appreciated from the foregoing, the disclosed embodiments of the present invention provide a passive RF tag system that

extracts a greater supply voltage from a received signal to achieve a greater transmission range. This increase in the communication distance enables use of passive RF tags for broader applications, such as tracking and identifying inventory in large warehouses, battlefield weaponry, and animals, without increasing the size and cost of such tags.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing objects, features and advantages of the present invention will be discussed in detail in the following non-limiting description of specific embodiments in connection with the accompanying drawings.

Figure 1 is a schematic of an existing RF tag system;

Figure 2 is a schematic of a remote communication system formed in accordance with the present invention;

Figure 3 is a schematic of a remote communication system formed in accordance with another embodiment of the present invention;

Figure 4 is a more detailed schematic of the tag of Figure 2;

Figure 5 is a block diagram of the identification circuit of the tag of Figure 4; and

Figure 6 is a more detailed schematic of the power circuit of the embodiment depicted in Figure 3.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 2, depicted therein is a remote communication system 26 in accordance with one embodiment of the present invention. The remote communication system 26 includes an energy source transmitter 28 configured to transmit an energy signal 30, and an interrogator 32 configured to transmit a first data signal 34 and to receive a second data signal 36. More particularly, the energy source transmitter 28 includes an antenna 38 configured

to transmit the energy signal at a first frequency. The interrogator 32 includes an antenna 40 configured to transmit the first data signal 34 at a second frequency and to receive the second data signal 36 at either a second frequency or, if desired, at a third frequency.

In one embodiment of the remote communication system 26, the energy source 28 and interrogator 32 can be separate components at either the same location or at different locations. In another embodiment, the energy source 28 and the interrogator 32 can be formed as a single integrated unit with two antennas. In yet another embodiment, the energy source 28 can be a parasitic source of energy, such as wall current, or radio frequency signals from outside transmitters, such as commercial radio stations, or even signals emitted by cell phones. Yet another source of energy could be light energy from natural or artificial sources.

On the receiving side, a transponder 42 is provided that includes a power circuit 44 and a identification circuit 46 coupled to the power circuit. The power circuit 44 has an antenna 48 to receive the energy signal 30. The power circuit is configured to rectify the energy signal to provide a supply voltage to the identification circuit 46. The identification circuit 46 has its own antenna 50 to receive the first data signal 34, which is transformed within the identification circuit 46 into the second data signal 36 that is then transmitted via the same antenna 50.

It is contemplated that only one antenna may be used on the interrogator and on the transponder; however, it is understood that each may have more than one antenna. Referring to Figure 3, illustrated therein is another remote communication system 52 formed in accordance with the present invention. The remote communications system 52 includes an interrogator 54 having an antenna 56 configured to transmit a first data signal 58 and to receive a second data signal 60. Also shown is a transponder in the form of a tag 62 having an antenna 64 to receive the first data signal 58, which is transformed by the tag 62 into the second data signal 60 that is transmitted from the antenna 64.

The antenna 64 is configured to also receive an energy signal 66 from an energy source 68. The tag 62 is configured to rectify the energy signal 66 into a supply voltage for supplying a DC current to circuitry in the tag 62. In this embodiment, the energy source can be a component of the interrogator 54, or it can be a separate transmitter, as in the embodiment shown in Figure 2, or it may be an external energy source, such as a parasitic energy source, as described more fully above with respect to Figure 2.

Figure 4 illustrates in more detail the power circuit 44 and the identification circuit 46 of the first embodiment shown in Figure 2. The power circuit 44 receives the energy signal 30 through the antenna 48, where it is rectified by first and second diodes 70, 72 and a resonant parallel RC circuit 74 composed of a resistor 76 and capacitor 78. The output of the power circuit 44 is the positive supply voltage (V+). This supply voltage (V+) is received by the identification circuit 46, which in this case is shown as an RFID application-specific integrated circuit (ASIC) 80. The details of a representative ASIC 80 are shown in Figure 5, including a power interface 82 configured to receive the supply voltage (V+). Power is distributed from the power interface 82 to a memory 84, a control circuit 86, and a modulation/demodulation circuit 88. The construction of these circuits is known to those skilled in the art and will not be described in detail herein.

Turning next to Figure 6, illustrated therein is a representative example of a portion of the circuitry in the single-antenna tag 62 illustrated in Figure 3. As shown in Figure 6, the antenna 64 receives the energy signal 66 and the first data signal 58. The antenna 64 is configured to absorb the energy signal 66 received at a first frequency f_1 and to be reflective of the first data signal 58, received at a second frequency f_2. In the embodiment depicted in Figure 6, the antenna is modulated by a FET transistor 90 controlled by a data signal (data) at its control gate. A rectifier circuit 92 is shown therein, having a construction identical to the circuit 74 shown in Figure 4 for generating the supply

voltage (V+). The second data signal 60 is generated by the FET transistor 90 for transmission by the antenna 64.

In all of the embodiments shown, a suitable antenna known to those skilled in the art can be used. For example, the antenna could be a quarter-wave dipole antenna that provides a delta of $1/4\ \lambda\ f_2$ for receiving the first data signal 58 and backscattering the second data signal 60.

In use, the system would preferably transmit the power signals at a low frequency such as 420 MHz, or at a frequency permitted by law. The first and second data signals would be transmitted at a higher frequency, such as 2450 MHz or 5800 MHz, again, as permitted by law. However, other frequencies may be used as known to those skilled in the art. For example, the laws of certain countries, such as the FCC in the United States, permit higher power transmission at higher frequencies under predefined conditions. Hence, the energy signal could be at a higher frequency than the data signal.

The disclosed embodiments of the present invention thus provide enhanced supply voltage for passive RF tags to achieve greater communication distance with one or more interrogation units. The received energy signal may be transmitted from the interrogation units or energy may be extracted from existing sources, such as near-by radio stations, or even sunlight, thus keeping the size and cost of the RF tag to a minimum while increasing its range and its usefulness.

CLOSURE

From the foregoing it will be appreciated that, although specific embodiments of the invention have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims and the equivalents thereof.

CLAIMS

We claim:

1. A remote communication device, comprising:

an antenna configured to receive a first signal and a second signal at a frequency different from the first signal, and to transmit a third signal;

a power circuit coupled to the antenna and configured to provide a supply voltage from the first signal; and

an identification circuit coupled to the antenna and the power circuit and configured to use the supply voltage to generate the third signal.

2. The device of claim 1, wherein the first and second signals are received simultaneously.

3. The device of claim 2, wherein the power circuit comprises a rectifier circuit configured to rectify the first signal into a DC supply voltage.

4. The device of claim 3, wherein the identification circuit is configured to generate the third signal by modulating the second signal.

5. The device of claim 4, wherein the first frequency is lower than the second frequency.

6. The device of claim 4, wherein the antenna comprises a first antenna for receiving the first signal and a second antenna for receiving the second signal and transmitting the third signal.

7. The device of claim 4, wherein the first, second, and third signals are radio frequency signals.

8. A remote communication device, comprising:

a transponder configured to receive an energy signal transmitted at a first frequency and to convert the energy signal into a supply voltage; and

to use the supply voltage to receive a second signal and to transmit a third signal in response to receipt of the second signal, the third signal transmitted at a second frequency that is different than the first frequency.

9. The device of claim 8, wherein the transponder is configured to transmit the third signal by continuous wave backscatter.

10. The device of claim 8, wherein the transponder is configured to rectify the energy signal into a DC supply voltage for use in receiving the second signal and transmitting the third signal.

11. The device of claim 8, wherein the transponder is configured to receive the energy signal and the second signal and to transmit the third signal via a single antenna.

12. The device of claim 8, wherein the transponder is configured to receive the energy signal via a first antenna and to receive the second signal and transmit the third signal via a second antenna.

13. The device of claim 8, wherein the transponder is configured to receive the energy signal in the form of light energy and to convert the light energy into a supply voltage.

14. The device of claim 8, wherein the transponder is configured to receive the energy signal in the form of a magnetic field and to convert the received magnetic field into a DC supply voltage.

15. The device of claim 8, wherein the transponder is configured to receive the energy signal in the form of a radio frequency signal and to convert the radio frequency into a DC supply voltage.

16. A remote communication system, comprising:

a source of radiated energy;

a transceiver configured to transmit a first data signal and to receive a second data signal; and

a transponder remote from the transceiver and configured to receive the radiated energy and to convert the radiated energy into a supply voltage, and to use the supply voltage to receive the first data signal and to transmit the second data signal in response to the first data signal.

17. The system of claim 16, wherein the source of radiated energy comprises a radio frequency transmitter configured to transmit the radiated energy at a first frequency that is different than the frequency of the first and second data signals.

18. The system of claim 17, wherein the transponder comprises a rectifier circuit configured to receive the radio frequency signal transmitting the radiated energy and to convert the same into the supply voltage that includes a DC current.

19. The system of claim 18, wherein the transponder is further configured to transform the first data signal into the second data signal by modulating the first data signal.

20. The system of claim 19, wherein the transponder comprises a first antenna for receiving the radio frequency signal having the radiated

energy and a second antenna for receiving and transmitting the first and second data signals, respectively.

21. The system of claim 20, wherein the transponder is configured to have a single antenna that is configured to receive both the radio frequency signal containing the radiated energy and the first data signal and to transmit the second data signal.

22. The system of claim 19, wherein the transceiver includes the radio frequency transmitter for the radiated energy, and further wherein the first data signal comprises an interrogation signal transmitted at a frequency that is higher than the frequency of the radiated energy transmitted by the radio frequency transmitter.

23. A remote communication system, comprising:

a transceiver configured to transmit an energy signal at a first frequency and to transmit a first data signal at a second frequency that is different than the first frequency; and

a transponder configured to receive the energy signal and convert the energy signal into a supply voltage, and to receive the first data signal and to transform the first data signal into a second data signal, and to transmit the second data signal to the transceiver.

24. The system of claim 23, wherein the transponder is configured to receive the energy signal via a first antenna, and to receive the first data signal and transmit the second data signal via a second antenna.

25. The system of claim 23, wherein the transponder is configured to receive the energy signal and the first data signal and to transmit the second data signal via a single antenna.

26. The system of claim 23, wherein the transponder is configured to rectify the energy signal into a DC supply voltage that is used to receive and transform the first data signal into the second data signal.

27. The system of claim 23, wherein the second data signal is transmitted by continuous wave backscatter.

28. A remote communication method, comprising:

receiving an energy signal and converting the energy signal into a supply voltage;

receiving a first data signal at a frequency different than the frequency of the energy signal; and

transforming the first data signal in accordance with a predetermined transformation scheme into a second data signal and transmitting the second data signal using the supply voltage.

29. The method of claim 28, wherein the energy signal and the first data signal are received simultaneously.

30. The method of claim 28, wherein transforming the first data signal into the second data signal comprises modulating the first data signal in accordance with a predetermined modulation scheme.

31. The method of claim 28 comprising initially transmitting the energy signal via a radio frequency carrier wave, and wherein receiving the energy signal comprises rectifying the radio frequency carrier wave to extract the supply voltage.

32. The method of claim 31, wherein the energy signal is received via a first antenna and the first data signal is received and the second data signal is transmitted via a second antenna.

33. The method of claim 28, wherein the energy signal and the first data signal are received and the second data signal is transmitted via a single antenna.

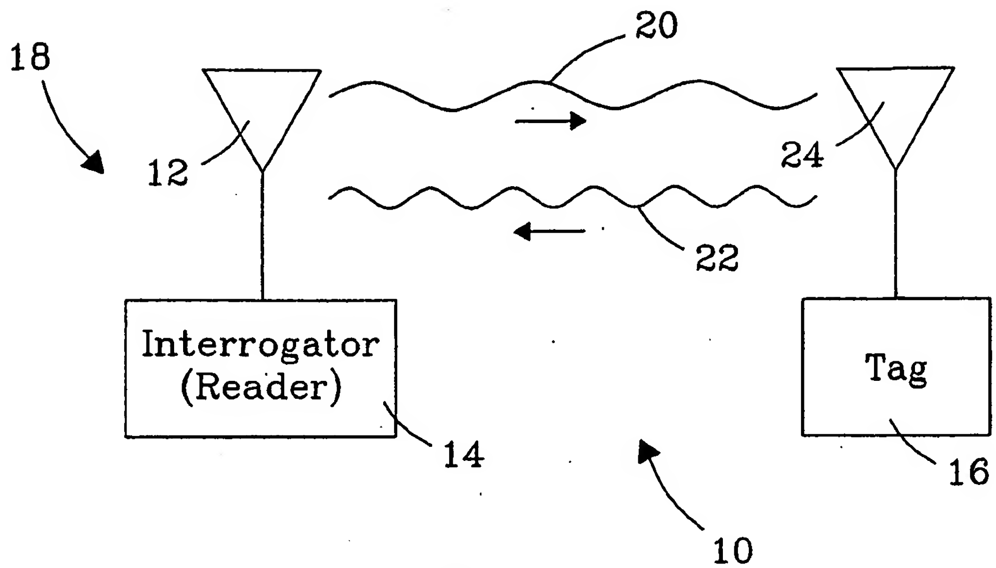


Fig. 1
(Prior Art)

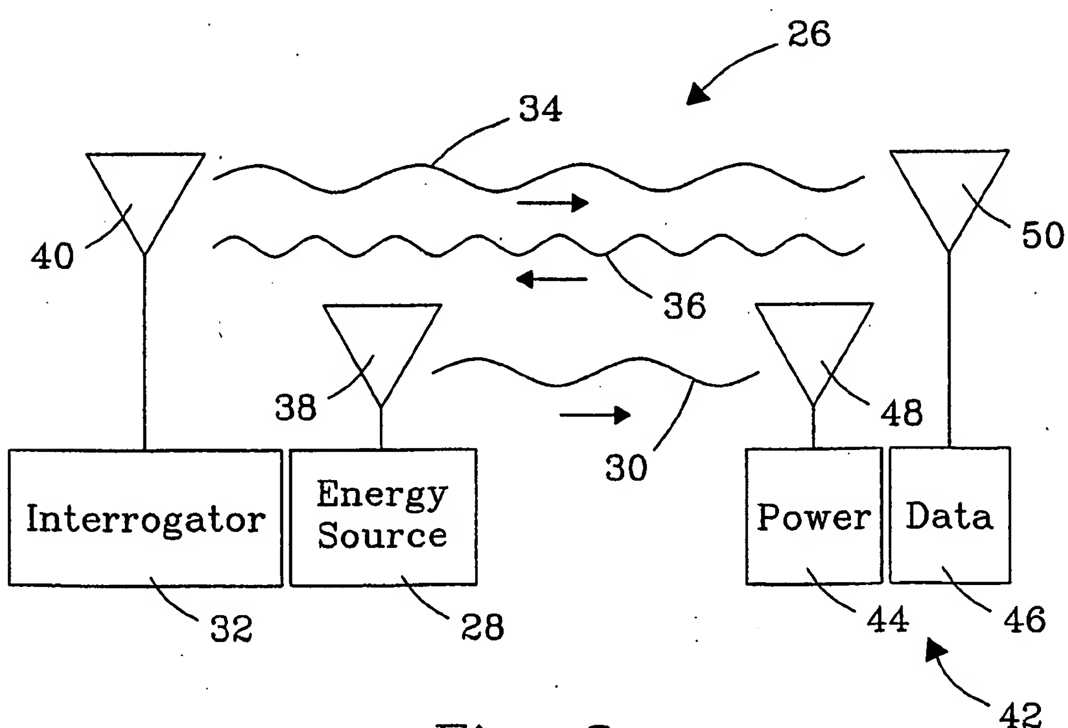


Fig. 2

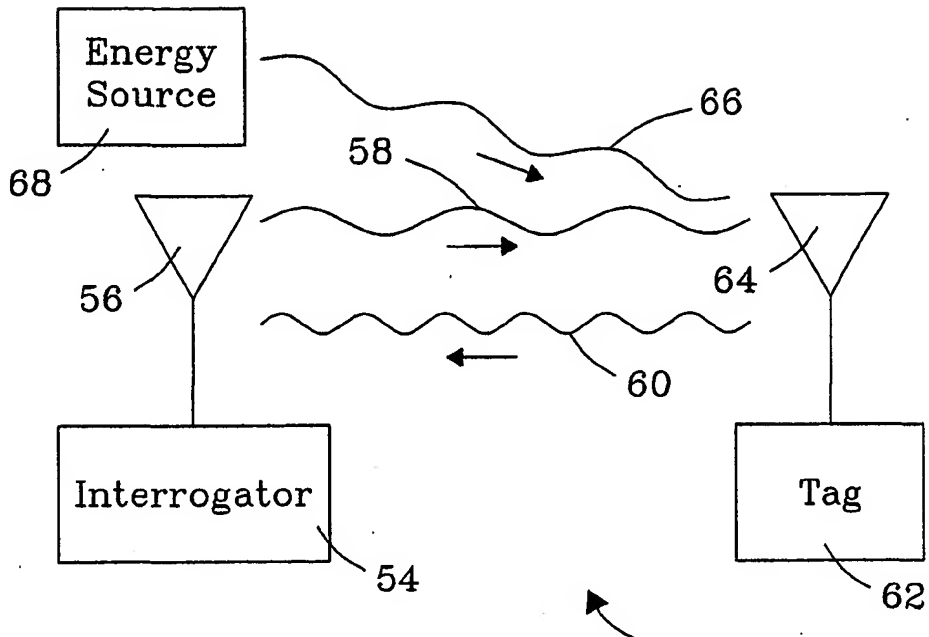
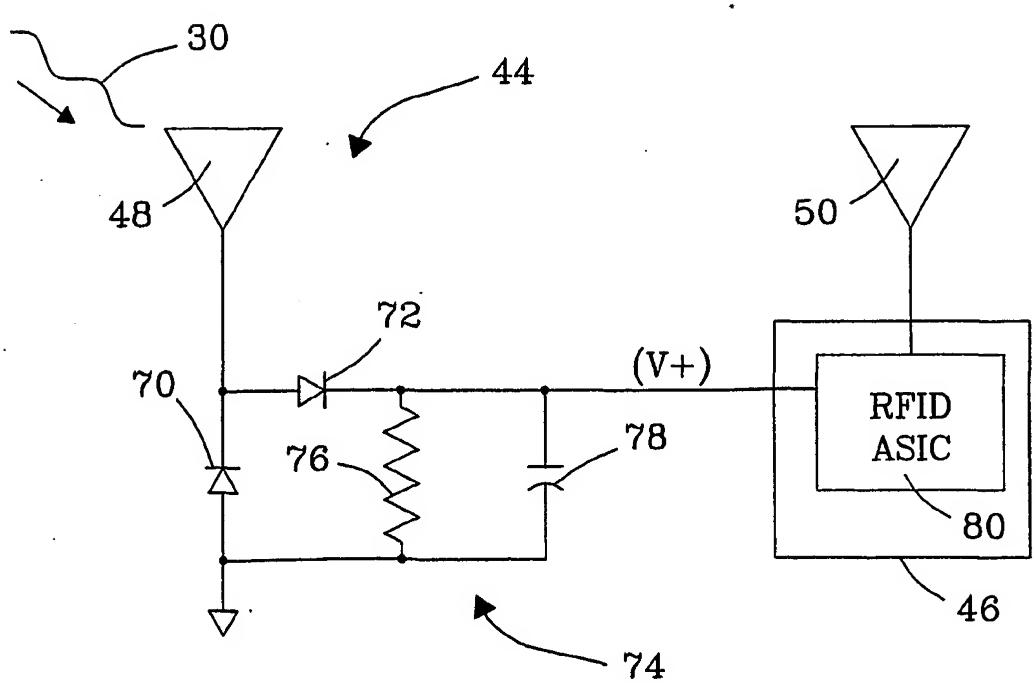

Energy Source
68
66
58
56
64
60
Interrogator
54
Tag
62
52

Fig. 3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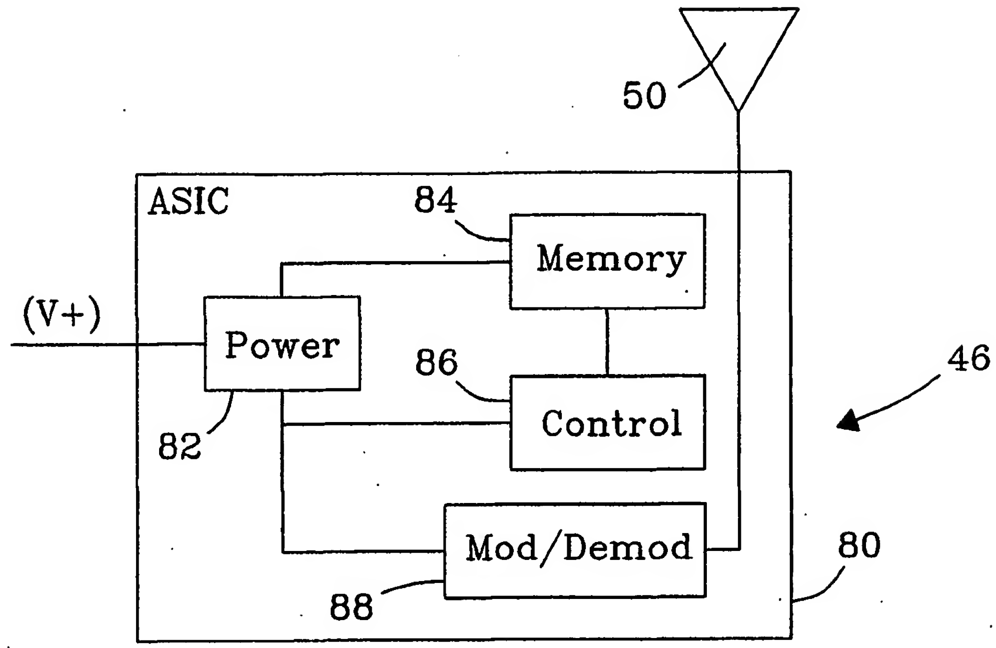
78
80
46
74

Fig. 4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(V+)
Power
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Control
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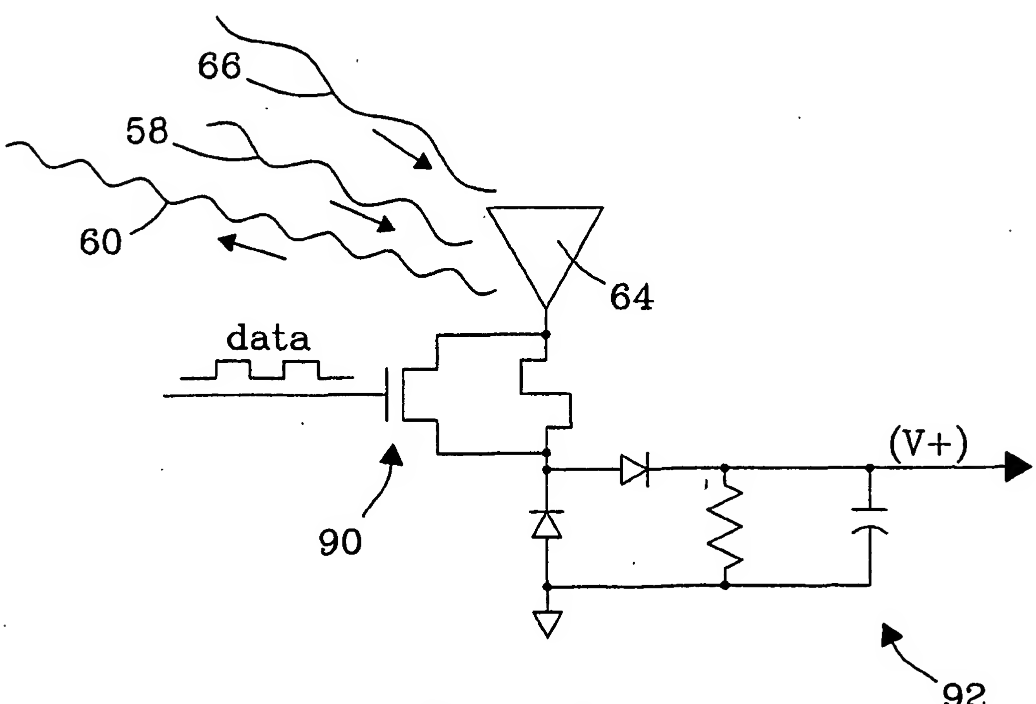
Mod/Demod
80
88

Fig. 5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60
64
data
(V+)
90
92

Fig. 6